REMARKS

The specification has been amended to insert a reference to the PCT application and the Swiss priority application. Paragraph 4 has been inserted to describe the prior art cited in the International Search Report. Spelling errors have been corrected and sub-titles were inserted. A substitute specification and marked-up copy thereof are enclosed.

All claims have been canceled and new claims 11-28 have been added.

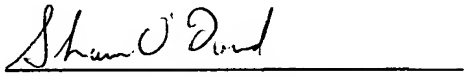
Examination in light of these amendments is respectfully requested.

The Examiner is invited to contact the undersigned at 202-220-4200 to discuss any matter in connection with this application.

The Office is hereby authorized to charge any fees under 37 C.F.R. 1.16 and 1.17 to the Kenyon & Kenyon Deposit Account No. 11-0600.

Respectfully submitted,

Dated: 22 December 2005



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SUBSTITUTE SPECIFICATION
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PISTON PUMP

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This is a 371 national phase application of International Application No. PCT/CH2004/000327 filed 01 June 2004, which claims priority to Swiss Application Number 1169/03 filed 02 July 2003, the contents of which are incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The invention is with regard to a piston pump with a pump casing and a piston that narrows the working chamber in a pump cylinder through an elevating motion, in accordance with the preamble of patent claim 1. The invention preferably deals with a piston pump to convey or meter fluid media of the most varied nature.

BACKGROUND OF THE INVENTION

[0003] Piston pumps are generally established in a multiplicity of design versions and serve the most varied conveying or driving requirements (hydraulics). Piston pumps established in process engineering ~~utilise~~ utilize only one front surface of the piston to fill and eject the pump medium. This results in unwanted pulsation which takes place in a sinusoidal manner in the case of a crank assembly for the intake and working stroke with its negative consequences on the Net Positive Suction Head (Net Positive Inlet Head) and on the cavitation respectively. Apart from this, the valve function is purely automatic in the case of these pump pistons i.e., the suction vacuum and the pressure of the working stroke respectively opens and closes the check valves respectively. Here one has good control of the kinematics of the valve function (closing time delay angle) only in the case of pure and clean fluids. The pre-condition for this, however, is that the pressure ratios of the installation systems should be easy to ~~customise~~ customize otherwise excess or low supply cannot be avoided. Particles of any type in the fluid pose a

problem, negatively influencing leak tightness and occasionally the mobility of the oscillating valve part. The source of the particles could vary; intentional as substance of content (suspension); unintentional as "dirt" from the installation system or as grit from the piston sealing. If the kinematics cannot be conveniently ~~customised~~ customized and/or particles in the fluid are unavoidable and/or are a desired component then one should not use this type of piston pump for quantitative metering without using metered stream gauging. In addition to this, the construction of this type of pump in the valve region becomes very complex if it is to be used for particle-laden fluids.

[0004] In GB M08480A in the realm of pressure engines for liquids, pumps and combustion engines, VANE FRANCIS BARRITT proposed furnishing the two operative sides of a pump with a valve control composed of a plurality of levers or something approximating it, in fact one for every valve in a pair, whereby a cam device which they have in common and which is driven by the connecting rod of the engine, acts upon the valve lever mentioned or upon something approximating it. His valve control emanates from a cam device that is composed of a slide valve or sliding block connected to a connecting rod and is triggered to follow a groove whose upper surface consists of the enlarged ends or buttons of a pivoted lever that are customized to control the valves. In FR 551 600 A, M. ARTHUR CASTELNAU later proposed a double operative pump whose opening or closing of the suction and discharge pipes were to take place with the help of a slide valve with a to and fro movement, whereby the slide valve glides on a shear panel or between two shear panels and is designed to pick up soft particulate matter lying in its path or to cut up same during its passage. With regard to excessively high liquid pressure in the very weak openings of the slots, he proposes insertion of one or several springs between the slide valve and the piston rod. Both inventions together have complex mechanics with many individual parts and thus many friction and wear surfaces. Apart from this, these proposed constructions are difficult to seal towards the exterior due to their many sliding and friction surfaces. A double operative piston

pump is proposed in DE 11 77 007 b (DEKA SA) whose inlet and discharge valves are coupled hydraulically to a piston each, whereby their cylinders are respectively connected in pairs to one another by means of a closed pipeline. It is rather unlikely that this proposal has been tried in practice since the marginal suction pressure in the inlet valve and its piston force respectively is not capable of maintaining a higher pump supply pressure over the connected pistons of the closing valves and so the same will therefore leak. In addition, this proposal has many sealed locations that collectively make it difficult to control the pump and its mechanism.

SUMMARY OF THE INVENTION

[0005] The task of the invention, therefore, is to make a piston pump of the type initially described available, which is low on pulsation and functions efficiently with just one piston, possesses positively controlled suction and pressure valves and has a simple, compact design.

[0006] This task is solved in accordance with the invention in that the piston narrows the working chamber in the pump cylinder at two sides with its upper and lower piston front surfaces and in that the working chamber is connected by every positively controlled inlet valve and by every positively controlled discharge valve that, alternating in each case, open and close respectively when the two end positions of the piston are reached for filling and ejection of the working volume. The piston's double impact, in accordance with the invention, results in an additional reduction of the working volume by the volume share of the piston rod per working stroke whereby the performance is almost doubled and a discharge stream with low pulsation results. Marginal residual pulsation exists only for the short period when valves change from "open" to "close" when the two extreme positions of the piston are reached in the cylinder. This residual pulsation can be ~~minimised~~ minimized by choosing a relatively large piston stroke when compared to the opening angle of the valve. Consistent streams of the pump medium are achieved by linear propulsion of the piston e.g. by using a

pneumatic cylinder, hydraulic cylinder, stroke magnet or linear motor. Other suggestions in accordance with the invention are that the inlet valves and discharge valves be connected to the piston in such a manner by a lever system that after reaching one of the extreme positions of the piston one inlet valve and one discharge valve opens and the other inlet valve and the other discharge valve closes respectively, mandatory in each case, and after reaching the other extreme position of the piston, it is mandatory that one inlet valve and one discharge valve closes and the other inlet valve and other discharge valve opens respectively. This simple, inventive solution of two inlet and two discharge valves that are connected in pairs by a lever system solves the problem of the two-sided piston impact in a simple manner. In particular, the piston pump does not hereby require any doubly driven inlet and discharge valves respectively but instead only requires two valve chambers that alternatively function as intake and pressure chambers. Mandatory opening and closing of the valves respectively effectively prevents wrong flow of the pump medium from the pressure socket into the intake socket and vice versa. An additional suggestion in accordance with the invention is that both inlet valves and both discharge valves respectively be located laterally reversed at a valve rod each. The task of synchronising the valve movements is thus solved in a simple manner with just two vacuum-sealed locations and a minimum of moving parts with only two valve rods. Another proposal for mandatory alternating movement of the inlet and discharge valves is that the valve rods alternatively pierce the valves, the pump casing and the valve lid on one side and are connected at the ends by a compensator whose one end is extended and movably connects the valve rods to the conveying lever by a plate. In order to achieve supply with low pulsation and for regulation of supply quantities, it is suggested, in accordance with the invention, that a cylinder with loaded pistons whose piston rod pierces the cylinder, be connected to the pump lid by a propelling lever and that this propelling lever should movably incorporate a propelling rod in the region between its two pivotal points, this propelling rod being

movably connected at the other end to the conveying lever. Propulsion should preferably take place with a pneumatic cylinder that is furnished with an automatic switch-over device at the two end positions of the piston. The piston pump can hereby also be used in ex-zones. A further suggestion in accordance with the invention for compactness and simplicity is that the pump casing should possess three bores that lie in an axis, whereby one bore forms the working chamber and the other two bores each with a cross hole, form the inlet and discharge channels respectively in such a manner that during pump operation the inlet valve and discharge valves close and open the bores at one end alternatively for the piston's elevating motion. The conveying lever hereby comes to lie in the middle of the pump's longitudinal axis through which the design turns out to be simple and space-saving. Mandatory operation of the valves is designed in such a manner in accordance with the invention that the valve rods have a screw thread with a nut at the end of that side that faces the pump lid and by screwing in or screwing out of which the distances of the valve pairs that are located laterally reversed, becomes smaller or greater for clearance adjustment. The valve seats can thereby be designed to be flat, conical or tapered. The most minimal stroke is achieved in the case of required valve opening cross-section with a flat seating valve. In order to ensure secure sealing in the case of particle-laden fluids and/or to reduce the precision of fit, valves can be designed to have an elastic coating. The structure of the piston pump, in accordance with the invention, enables driving two or a larger number of piston pumps synchronously by coupling their propelling lever to a common piston rod. In this regard it is proposed in accordance with the invention, that the pumps to be coupled preferably lie vertically one over the other in such a manner that the propelling rods can be connected directly to the cylinder lying under it whereby all pumps have a common propulsion at their disposal. Wherever there is a constraint of space, two or several pumps can also be located next to one another and be synchronously operated by a common connection of their piston rods. A pneumatic cylinder with a flip-

flop switching mechanism is preferable for propulsion. Every type of linear propulsion or crank assembly is, however, suitable for connection. In the case of a crank assembly, the supply stream is however sinusoidal with a negative impact on the Net Positive Suction Head NPSH. Supply quantities in the case of constant stroke frequency can be regulated in accordance with the invention by modifying the supply stroke individually in the case of every coupled pump by pushing their propelling rods to their propelling lever.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The invention is explained in greater detail with illustrations using only one design.

[0008] Figure 1 is the longitudinal view of the piston pump.

[0009] Figure 2 represents section A-A running through the piston pump and

[00010] Figure 3 is the sheer plan of two coupled pump pistons.

DETAILED DESCRIPTION

[00011] A pump casing 1, 2, 3 is illustrated in Figure 1 with a pump cylinder 5 in which a piston pump 4 that is sealed with an O-Ring 6 is driven by a piston rod 7. The piston, sealed by an O-Ring 6 and a gasket 9 rod, pierces the pump casing 3 and the valve lid 8 with its end that faces away from the pump piston 4 and is connected at its end by a compensator 19 whose end is elongated and movably connects the valve rods 11, 15 to the conveying lever 25 through a plate 22. The conveying lever 25 pivots with anti-friction bushes 23, 26, 27, and is connected to the propelling lever 31 by a propelling rod 28. The propelling rod 31 is dissected in the middle so that the conveying lever 25 can be modified using a removable bolt 32 at its point of application. The pump piston's 4 stroke can thus be increased or reduced. The propelling lever 31 is connected in joints at one end to the pump lid 2

and with its other end to the piston rod 35 by bolts 33, 34. The piston rod 35 protrudes from a pneumatic cylinder 36 that is controlled in such a manner that it automatically moves to and fro permanently (flip-flop switching mechanism). It is preferable that this take place through two magnetic switches and two pneumatic valves for both piston end positions. The valve lid 8 is distanced from the base plate 29 by four distancing rods 30. The compensator 19 is supported by an anti-friction bush 21 on the elevation of the valve lid 8 in the middle of the two valve rods 11, 15. The compensator 19 is somewhat elongated at that end that faces away from the pump piston 4 and, pivoting over anti-friction bushes 23, 24, is connected to a plate 22. This elongation of the compensator 19 i.e., the distance between the force effect through the plate 22 and the pivoting point 21 of the compensator 19 is to be selected in such a manner that the expenditure of energy required to operate the valve rods 11, 15 over the pivoting points 18, 20 must be manifestly lower than the energy expended to move the pump piston. The conveying lever 25 would otherwise turn only at the pivoting point 23 without moving the valve rods 11, 15.

[00012] Figure 2 illustrates section A-A through the piston pump in the middle of the inlet valves 14, 16. This cross-section shows the inlet port c in particular which, depending on the position of the two valves 14, 16 that are located laterally reversed up or down, close and open respectively.

[00013] Figure 3 illustrates a sheer plan of the two piston pumps that are connected one over the other in accordance with Figure 1 with a common pneumatic cylinder 36 providing propulsion. The piston rod 35 of this pneumatic cylinder 36 drives an extension rod 38 through a rotating bolt connection 37, this rod for its part propelling the conveying lever 40 of a second piston pump through a rotating bolt connection 39. Here the conveying lever 40 has a recess that contains a spindle with spindle nut 43 between its pivotal points 39, 45, to which the propelling rod 44 is fixed in joints. By turning the hand wheel 42, the spindle nut 43 and with it, the

propelling rod 44 runs in the direction of the piston pump or in the direction of the hand wheel 42. The piston stroke of the two pumps that are coupled is hereby modified, whereby the modified supply quantities to the first pump can be set by the same bore of the supply cylinder.